NEWS **SCIENCE** NEWS

DEW PONDS, AIR WELLS AND FOG TRAPS

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Humans need to drink at least two quarts [just over two litres] of water daily to remain alive. If groundwater is not available, the atmosphere humidity can be condensed instead to provide our minimum requirements.

In 1993, Reginald E. Newell (of MIT) found 10 huge "atmospheric rivers" (five each in the northern and southern hemispheres) with typical flow rates of 165 million kilograms of water per second. These rivers of vapour are bands up to 480 miles wide and 4,800 miles long, about 1.9 miles above the Earth. They are the main means of transporting water from the equator. It should be possible to draw water from these rivers. The problem of accessing that height is not insurmountable, especially if the construction is done atop mountains.[1]

The means of collecting atmospheric humidity is an ancient technology that has been largely ignored in modern times. The most impressive example of this science was discovered in 1900–03 during the excavation of Theodosia (a Byzantine city dating to about 500 BC).

Archaeologists found numerous pipes, about three inches in diameter, leading to wells and fountains in the city. The pipes were traced to a nearby hill and were found to originate from 13 piles of limestone, each about 40 feet tall and 100 feet square. This system of "air wells" produced as much as 14,000 gallons of water daily!

Dew Ponds

Dew ponds have existed since prehistoric times, but today the technology is nearly forgotten. A few unfailing dew ponds can still be found on the highest ridges of England's bleak Sussex Downs and on the Marlborough and Wiltshire Hills. Though far from any marshes, springs or streams, they always contain some water that condenses from the air during the night.

Arthur J. Hubbard described a dew pond in his book, *Neolithic Dew-Ponds and Cattleways* (1907):

"There is [in England] at least one wandering gang of men…who will construct for the modern farmer a pond which, in any suitable situation in a sufficiently dry soil, will always contains water. The water is not derived from springs or rainfall, and is speedily lost if even the smallest rivulet is allowed to flow into the pond.

"The gang of dew-pond makers commence operations by hollowing out the earth for a space far in excess of the apparent requirements of the proposed pond. They then thickly cover the whole of the hollow with a coating of dry straw. The straw in turn is covered by a layer of well-chosen, finely puddled clay, and the upper surface of the clay is then closely strewn with stones. Care has to be taken that the margin of the straw is effectively protected by clay. The pond will eventually become filled with water, the more rapidly the larger it is, even though no rain may fall.

"If such a structure is situated on the summit of a down, during the warmth of a summer day the earth will have stored a considerable amount of heat, while the pond, protected from this heat by the non-conductivity of the straw, is at the same time chilled by the process of evaporation from the puddled clay.

"The consequence is that during the night the warm air is condensed on the surface of the cold clay. As the condensation during the night is in excess of the evaporation during the day, the pond becomes, night by night, gradually filled. Theoretically, we may observe that during the day, the air being comparatively charged with moisture, evaporation is necessarily less than the precipitation during the night. In practice, it is found that the pond will constantly yield a supply of the purest water.

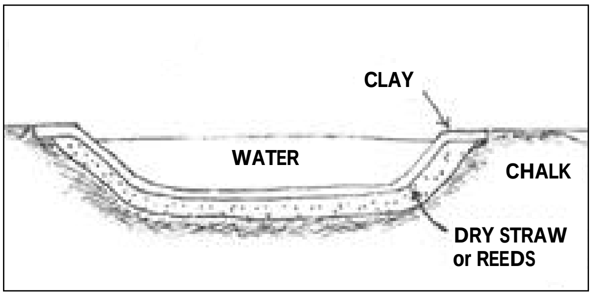
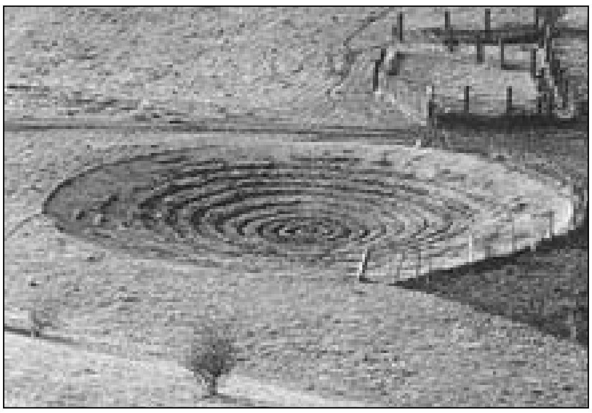


Figure 1: Dew Pond

"The dew pond will cease to attract the dew if the layer of straw should get wet, as it then becomes of the same temperature as the surrounding earth and ceases to be a non-conductor of heat. This practically always occurs if a spring is allowed to flow into the pond, or if the layer of clay (technically called the 'crust') is pierced."

Additional construction details were explained in *Scientific American* (May 1934):

"An essential feature of the dew pond is its impervious bottom, enabling it to retain all the water it gathers, except what is lost by evaporation, drunk by cattle or withdrawn by man. The mode of construction varies in some details. The bottom commonly consists of a layer of puddled chalk or clay, over which is strewn a layer of rubble to prevent perforation by the hoofs of animals. A layer of straw is often added, above or below the chalk or clay. The ponds may measure from 30 to 70 feet across, and the depth does not exceed three or four feet."[2]



Spiral Dew Pond, Oxteddle Bottom, Sussex, 1997 (Photo: Chris Drury)

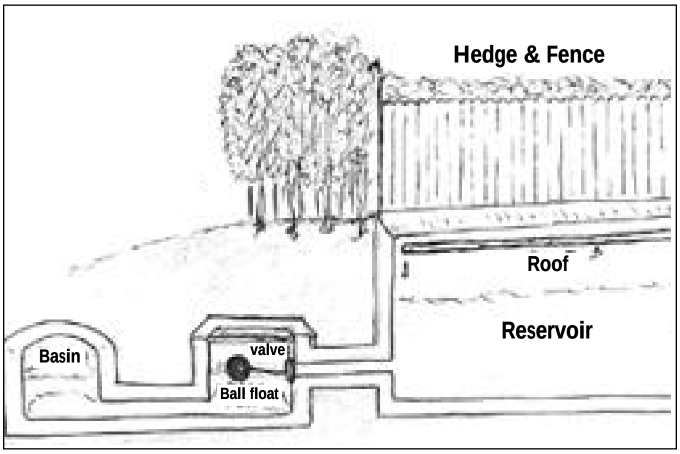


Figure 2: Russell's Dew Pond

Another form of dew pond was invented by S. B. Russell in the 1920s. It was described in *Popular Science* (September 1922):

"A dew reservoir 30 feet square will collect 24,000 gallons of water in a year, or an average of 120 gallons daily during the hot summer months and 50 gallons daily for the remainder of the year…

"The Russell reservoir consists of a concrete cistern about 5 feet deep, with sloping concrete roof, above which is a protective fence of corrugated iron which aids in collecting and condensing vapor on the roof and prevents evaporation by the wind. The floor of the cistern is flush with the ground, while sloping banks of earth around the sides lead up to the roof.

"Moisture draining into the reservoir from the low side of the roof maintains the roof at a lower temperature than the atmosphere, thus assuring continuous condensation.

"At one side of the reservoir is a concrete basin set in the ground. By means of a ball valve, this basin is automatically kept full of water drawn from the reservoir."[3]

Air Wells

• In 1930, the Belgian inventor **Achille Knapen** built an "air well" atop a 600-foot-high hill at Trans-en-Provence in France. Its construction took him 18 months to complete. The unique structure was described in *Popular Mechanics* magazine:

"The tower…is about 45 feet tall. The walls are from 8 to 10 feet thick to prevent the heat radiation from the ground from influencing the inside temperature. It is estimated that the aerial well will yield 7,500 gallons of water per 900 square feet of condensation surface."[4]

An article in *Popular Science* magazine (March 1933) also featured Knapen's air well and included these details of its construction:

"[The air well has] a mushroom-like inner core of concrete, pierced with numerous ducts for the circulation of air; and a central pipe with its upper opening above the top of the outer dome.

"At night, cold air pours down the central pipe and circulates through the core… By morning the whole inner mass is so thoroughly chilled that it will maintain its reduced temperature for a good part of the day. The well is now ready to function.

"Warm, moist, outdoor air enters the central chamber, as the daytime temperature rises, through the upper ducts in the outer wall. It immediately strikes the chilled core, which is studded with rows of slates to increase the cooling surface. The air, chilled by the contact, gives up its moisture upon the slates. As it cools, it gets heavier and descends, finally leaving the chamber by way of the lower ducts. Meanwhile, the moisture trickles from the slates and falls into a collecting basin at the bottom of the well."[5, 6]

Unfortunately, however, the structure did not perform as hoped; at best, it collected only about five gallons per night.

Knapen was inspired by the work of bioclimatologist Leon Chaptal, who built a small air well near Montpellier in 1929. The pyramidal concrete structure was 3 metres square by 2.5 metres in height (10 x 10 x 8 feet), with rings of small vent holes at the top and bottom. Its 8 cubic metres of volume was filled with pieces of limestone (5–10 cm) that condensed the atmospheric vapour and collected it in a reservoir. The yield ranged from 1–2.5 litres/day from March to September. In 1930, the structure collected about 100 litres from April to

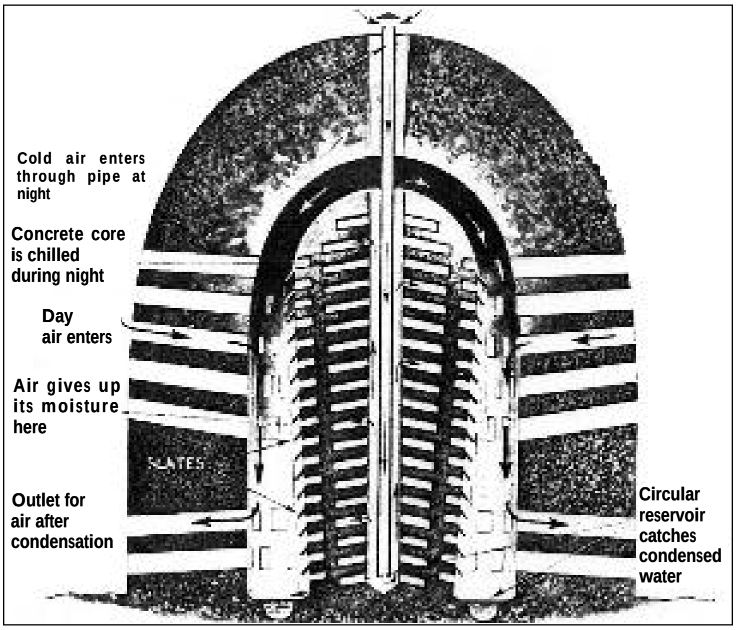
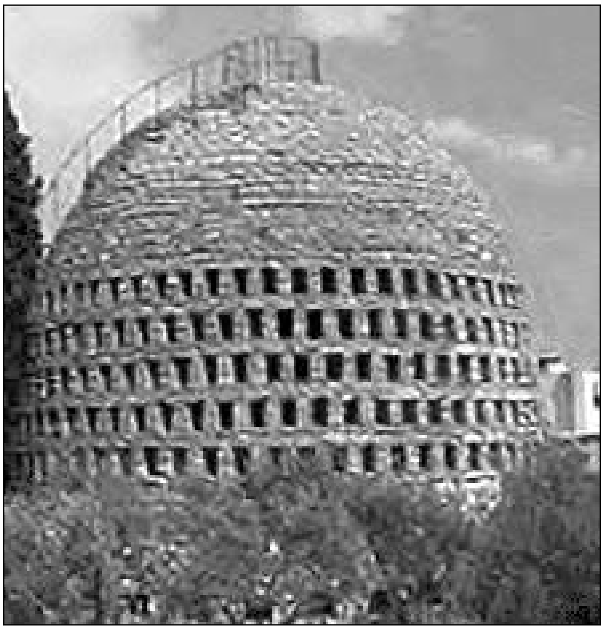


Figure 3: Knapen's Air Well



Knapen Air Well (Photo: International Organization For Dew Utilization)

September, but only half that much in 1931. The maximum yield was 5.5 lb/day.

Chaptal found that the condensing surface must be rough, and the surface tension sufficiently low that the condensed water can drip. The incoming air must be moist and damp. The low interior temperature is established by re-radiation at night and by the lower temperature of the soil. Air flow was controlled by plugging or opening the vent holes as necessary.

Chaptal drew his inspiration from a surprisingly successful experiment by Friedrick Ziebold, who constructed an atmospheric condenser atop a hill at Feodosia (Theodosia), Crimea, modelled after the ancient air wells discovered there in 1900. Ziebold's condenser was a pile of sea pebbles (10–40 cm diam.), 20 metres in diameter and 1.15 metres high. The construction yielded up to 360 litres/day until 1915, when it began to leak due to a crack in the wall.

• **Calice Courneya** patented an air well in 1982 (USP #4,351,651):

"A heat exchanger at or near subsurface temperature…is in air communication with the atmosphere for allowing atmospheric moisture–laden air to enter, pass through, cool, arrive at its dew point, allow the moisture to precipitate out, and allow the air to pass outward to the atmosphere again. Suitable apparatus may be provided to restrict air flow and allow sufficient residence time of the air in the heat exchanger to allow sufficient precipitation. Furthermore, filtration may be provided on the air input, and a means for creating a [negative] movement pressure, in the preferred form of a turbine, may be provided on the output…

"The air well is buried about 9 feet deep. The entrance pipe is 3-inch diameter PVC pipe (10 feet long), terminating just near the ground… This is an advantage because the greatest humidity in the atmosphere is near the surface."[7, 8]

In a preferred embodiment, the intake is provided with a cyclone separator to precipitate dust before the air enters the pipe. In addition, a flow restrictor device can be installed before the exit port.

Air flows through the pipes at 2,000 cubic feet per hour at 45°F with a 5 mph wind. This translates to about 48,000 $feet^3$/day (over 3,000 lb of air daily).

Courneya's first air-well used a turbine fan to pull air through the pipes. Later designs employed an electric fan for greater airflow. At 90°F and 80% relative humidity (RH), the air well yields about 60 lb water daily. At 20% RH, the yield is only about 3 lb/day. The yield is even lower at lower temperatures.

It is difficult to calculate the amount of water that can be collected. The yield depends on the amount of air and its relative and specific humidity, and the soil temperature, thermal conductivity and moisture. Acoustic resonance within the pipes might enhance condensation. The more recent invention of acoustic refrigeration could be used to advantage, as well as the Hilsch–Ranque vortex tube.

The water collected by the Courneya air well is relatively pure, equivalent to single-distilled water. Analysis of water collected by an air well near a busy street found no sulphur or lead (measured in ppm).

Friedrick Ziebold's Atmospheric Condenser, Feodosia, Crimea, 1912
(Photo: International Organization For Dew Utilization)

• In the 1950s, the French inventor **Henri Coanda** designed an elegant method to produce pure water from saline. He designed an enormous silo with reflective walls, which was mounted several inches over a tidal pool. The silo was angled so as to catch and multiply the sunlight, thus superheating the air in the chimney. The rising hot air drew in cold air from the bottom, and became super-saturated with moisture by the time it reached the top. Fans then pulled the air through a condenser, from which pure water flowed.

The residual brine is of great value to the chemical industry and in the construction of solar ponds. The French government forced Coanda to cease operations because his device threatened their monopoly on salt production.

Coanda described his "Apparatus for Purification of Undrinkable Water" as follows in the abstract of his USP #2,803,591:

"Apparatus for the purification of non-potable water comprising, in combination, an installation for heating a circulating mass of air, said installation comprising at least one tubular element through which said air circulates and at least one trough-like mirror of parabolic section having the focal axis thereof horizontally disposed, with said tubular element disposed along said focal axis of said mirror, said mirror with its associated tubular element being mounted in the plane of symmetry of said mirror, and also being mounted to rotate about a vertical axis…"[9, 10]

Coanda also received USP #2,761,292 for his "Device for Obtaining Drinkable Water". He offered the following explanation:

"It is known that the air contains water, and according to my invention the energy for precipitating this water can be taken from the air itself in motion. It is known that for a given temperature a given volume of air may not contain more than a certain quantity of water vapour. When it contains this quantity it is said to have reached its saturation point. Moreover, this point varies with the temperature, and the cooler the air, the less water vapour it may contain for a given volume.

"Consequently, when a relatively warm volume of moist air is cooled to a sufficiently low temperature, it yields the water it contained in excess over the quantity permitted by the saturation point at the temperature to which it has been cooled.

"In a continuous process of producing fresh water, it is necessary to absorb the heat derived from the warm moist air at a speed corresponding to the rate of cooling…"

Coanda recommended that the condenser be buried so that the earth could absorb the heat:

"For example, one cubic metre of air from a wind whose temperature is about 40°C can contain up to about 50 grams of water vapour; if the wind is forced to enter a certain space by passing along…a radiator in which a fluid circulates at the temperature existing 7 or 8 metres below the ground level, that is, of about 11°C, this wind will immediately precipitate on the radiator walls the portion of the water content which is in excess of that permitted by its saturation point at the cooler temperature, that is, about 40 grams per cubic metre of air, as the saturation point of air at 11°C is 10 grams per cubic metre. The heat given off, which must be carried away by the fluid in the radiator, represents approximately 32 calories for said one cubic metre of air…

"It is advisable to pass the fluid through a second radiator of larger dimension, disposed in the ground at a certain depth.

"If the humidity of the warm air is definitely below 50 grams of water per cubic metre, that is, if the air is far from its saturation limit, and if the device for obtaining fresh water is disposed near the sea, it is possible to use [windmills] for spraying sea water into the warm air in fine droplets, thereby increasing the amount of water contained in the warm air through the partial evaporation of the sea water thereinto…"

Other humidity condensers have been built in recent years. Soviet cosmonauts aboard space station *Mir* used a system that recovered water from the air. The Aqua-Cycle, invented by William Madison, was introduced in 1992. It resembles a drinking fountain and functions as such, but it is not connected to any plumbing. It contains a refrigerated dehumidifier and a triple-purification system (carbon, deionisation and UV light) that produces water as pure as triple-distilled. Under optimal operating conditions (80°/60% humidity), the unit can produce up to five gallons daily.

Cloud Condensers and Fog Fences

In 1945, South Africa's chief meteorologist, Theodore Schumann, proposed the construction of a unique **Cloud Condenser** on top of the 3,000-foot Table Mountain on the south side of Capetown. Schumann's design comprised two large parallel fences of wire netting, one insulated and one grounded, which would be charged with a potential difference of 50–100 kV. The wire screens were to be about 150 feet high, 9,000 feet long, and one foot apart. He estimated that the electrified fence would condense as much as 30,000,000 gallons daily from "The Cloth", a perpetual cloud that crowns the peak. The fence was never built.

Alvin Marks invented the **Power Fence** to generate electricity from the wind by means of a charged aerosol which was dispersed from microscopic holes in the tubing of the fence. Marks calculated that if the wind averaged 25 mph, a mile of fence would generate about 40 megawatts of power. The towers would be 500 feet high, strung with a grid of steel bars in a rectangular array, subdivided into a lattice of four-inch squares which are further divided by a mesh of perforated tubules through which the water flows. Marks's patent states that the system can be used to modify weather and to clear fog.[11, 12]

The EGD **Fog Dispersal System**, invented by Meredith Gourdine, has been used at Los Angeles and Ontario international airports and by the Air Force since 1986. The system uses an electrically charged mist that is sprayed into the fog over runways, thus clearing them for landing:

"[The system is comprised of] an array of charged submicron water droplet nozzles [and select] characteristics of a cloud of charged droplets…including a field strength…a charge concentration, a time constant, [etc.] whereby clearing of the air-borne particles occurs…by attachment of the emitted submicron droplets to the air-borne particles to the ground."[13, 14]

Soviet cosmonauts aboard space station *Mir* used a system that recovered water from the air.

A similar system was invented by Hendricus Loos (USP #4,475,927):

"[The system consists of] gapped air jets laden with electrically charged droplets of low mobility, a ground corona guard in the form of a shallow water-and-oil basin, and a charged-collector-drops emitting device on the ground, arranged in such a manner that the low-mobility charged droplets blown aloft by the air jets form a virtual electrode suspended at an appropriate height above the ground, toward which the oppositely charged high-mobility collector drops move, thereby collecting the neutral fog drops in their paths…"[15]

Chilean scientists have developed a revolutionary **Fog Trap** at Chungungo, Chile. A group of 50 fog traps made of plastic mesh stands atop a 2,600-foot mountain, collecting up to 2,000 gallons daily. The villagers call it "harvesting the clouds".

Walter Canto, regional director of Chile's national Forest Corporation, said: "We're not only giving Chungungo all the water it needs, but we have enough water to start forests around the area that within five or six years will be totally self-sustaining."

Another 21 sites (1,000 acres total) on the Pacific coast of Latin America also have fog traps. Some of the locations have become self-sufficient because the trees have become large enough to collect fog for themselves, just as the ecosystem did before settlers disrupted it. Fog-forest ecosystems survive precariously on droplets of water collected by their leaves. Some such forests, surrounded by deserts, have been sustained by fog for millennia. Very little cutting is necessary to initiate gradual but complete destruction.

The ideal locations for fog traps are arid or semi-arid coastal regions with cold off-shore currents and a mountain range within 15 miles of the coast, rising 1,500 to 3,000 feet above sea level. Mesh occupying 70% of the space is most effective for trapping fog droplets. Two layers of mesh, erected so as to rub together, optimise the collection of water in PVC pipes attached to the bottom of the nets. Collection varies with the topography and the density of the fog. The fog trap at Chungungo is 40 x 13 feet and produces 45 gallons/day. As the fog becomes denser and more frequent in the summertime, water production doubles.

Air wells, dew ponds and fog fences offer real hope for thirsty humanity. The quantity of water thus produced is not likely to meet the needs of large-scale agriculture, yet countless lives can be saved by this simple, elegant technology. ∞

Endnotes

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(Source: By Robert Nelson, Rex Research, http://www.rexresearch.com)